# PERFORMANCE INDICATOR FOR PUBLIC EXPENDITURE EFFICIENCY IN THAI BASIC EDUCATION: DATA ENVELOPMENT ANALYSIS APPROACH FOR THE FUTURE IMPROVEMENT

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**Abstract:** The purposes of this paper are 1) to develop a model to measure the performance of public expenditure in Thai basic education 2) to identify the association between efficiency score and school size by using Pearson moment correlation. The data for the study were obtained from following sources. The National Institute of Educational Testing Service (NIETS) and the office for National Education Standards and Quality Assessment (ONESQA) over the period 2007-2008. To identify the best performance schools, The Data Envelopment Analysis (DEA) methodology enables to aggregate performance indicators in order to obtain a public expenditure efficiency measure through the comparison of 164 Thai basic education schools. Moreover, the second stage Pearson product moment correlation was used to assess whether there is a relationship between efficiency score and school size.

The research findings were summarized as follows:

1. The average efficiency of these schools is 0.706 (primary school) and 0.713 (secondary school) which is quite high. However, efficiency scores of individual schools range from 0.191 to 1, which shows that some schools are significantly less productive.

2. The correlation analysis found the significant positive relationship between school size and efficiency score at 5% significance level.

**Keywords:** Efficiency, Basic Education, Data Envelopment Analysis

## Introduction

In spite of the significant changes in educational reform in Thailand, The educational results are below the majority of other developed countries (OECD, 2004). Thailand faces major problem with low academic achievement, which is significantly below all other OECD countries.

However, Thai government spending account for 21% of GDP in education. While OECD countries expended an average of 6.2% of GDP (OEDC, 2004) which means that Thailand education's expenditure relatively large but the Thailand educational outcome have shown under standard. This unsatisfactory result had raised serious questions about the school performance and efficiency of public school in Thailand.

The recent study (Afonso and Aubyn, 2006) evaluated the efficiency of expenditure in education provision by comparing the PISA results from the educational system of 25 countries and the result yielded that Thailand is the third least efficient school. This finding confirmed the poor public expenditure performance in Thailand.

Under this circumstance, measuring public expenditure performance is very important for Thailand. To identify and to improved efficiency of public spending not only help sustain the fiscal discipline requested by the Stability and Growth Pact but is also instrumental in promoting the structural reform agenda. It relieve budget constraints as it allows achieving the same results at lower levels of spending or increases value for money by achieving better outcomes at the same level of spending.

Analysis of educational system can identify efficient and less efficient schools and find determinants of efficiency, which provides educational policy makers useful information on how educational quality can be improved. Small changes in the efficiency of public spending can have a significant impact on education outcomes without an increase in resources.

In order to identify efficiencies, the first step is to identify which schools have been relatively successful in education goals after controlling for educational resources. A second step would be to

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examine why is some schools are schooling better than others with in their resource-level to achieve outcomes. If the school is found to be relatively productive or efficient but has to attain a given desirable outcomes. This circumstance imply that additional resources outlays are most likely going to be needed for achieving further progress. On the other hand, a school is inefficient relatively then this implies that increasing efficiency at this resource-level would improve the outcomes. Moreover, identification is a first step toward understanding factors that contribute to inefficiencies.

**Research Objectives**

The first aim of this paper is development of a model to measure the performance of public expenditure in Thai basic education. A performance measurement model for Thai basic education, using data envelopment analysis (DEA). This methodology designed for estimating performance of public schools that use multiple resources as educational (inputs) and produce multiple educational outcomes (outputs). The second aim of the paper, to identification of the association between efficiency score and school size by using Pearson moment correlation.

**Literature Review**

Effectiveness differs from efficiency. The former means that a school achieves high results no matter how much resources are used. The later means that a school achieves maximum results possible with the limited resources it has. This corresponds to the definition of a production function, which yields maximum possible output at a given level of input. In this case, schools may be represented as production units that use inputs to produce outputs. Moreover, one cannot say what the maximum level of output possible is; one can estimate it by observing the schools that produce most outputs at the given level of input. Then, inefficiency is measured by using the distance between the most efficient schools and a given school. This is the basic concept of DEA.

To estimate efficiency one should determine both inputs and outputs of a production unit. Moreover, in case of schools there are several outputs such as standardized score in different subjects. Some schools may perform better in one subject while the other in another subject. To measure these schools' performance, both outputs should be used. The regression analysis cannot use both outputs so it does not reflect different aspects of the school performance. It is hardly to combine different outputs in a single measure because it is difficult to specify weights for achievements in different subjects. As DEA can estimate efficiency with multiple-inputs and outputs, the DEA is an appropriate method to estimate efficiency by comparing a school to the best performing school.

The concept of efficiency to measure performance of organization was first developed by Farrel (1957) who measure efficiency using the distance between the production frontier and a giving unit. Later, Charnes at al. (1978) developed DEA to evaluate public school. Since then DEA become a standard model to estimate efficiency and it was extensively used in other organizations.

DEA evaluates each school called decision-making unit (DMU) with all other schools and calculates an aggregate performance measure based on a ratio of outputs and inputs. To measure school performance, DEA can deal with multiple inputs and multiple outputs. With this information, the DEA model determines the observed frontier of performance, based on the schools that perform better relative to all others with 100% efficiency score. The score is proportionally decreased depend on how far the distance between the frontier and a given schools.

The DEA model can be either input or output oriented. The input-oriented DEA model estimate efficiency by how much input can be decreased proportionally without reduces quality or quantity of inputs. In addition, the output-oriented DEA model focuses on how much output can be proportionally raised without additional inputs and this method is taken in this paper. These two models provide the same set of efficient school or inefficient school.

Assume for the purposes of illustration the

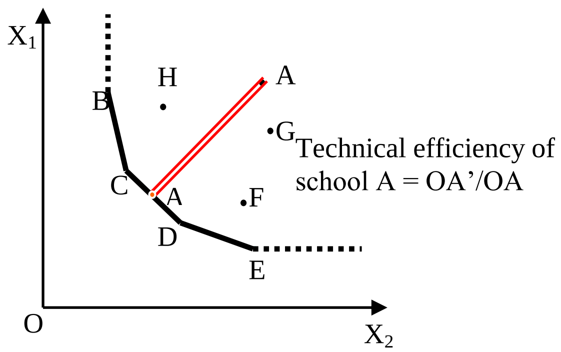


**Figure 1: Scatter Diagram Showing Efficient Frontier**

concept of DEA model for measuring efficiency score of 8 schools from A to H. These schools all produce one same level of output with two various level inputs ($X_1$ and $X_2$). The efficiency of the schools could be shown in a scatter diagram in figure 1.

The efficient frontier "envelops" the inefficient schools and clearly shows the relative performance of each school. Any school on the frontier receives a score of 1 and is considered a best performance school. Any school beyond the frontier receives a proportionally lower score.

In this example, four schools are the most efficient schools (B, C, D and E). The frontier represents a standard of best-achieved performance.

The analytical description of the DEA model is sketched below. Suppose there are p inputs and q outputs for n schools. For the i-th school, $y_i$ is the column vector of the outputs and $x_i$ is the column vector of the inputs. We can also define X as the ( p x n) input matrix and Y as the ( q x n) output matrix. The DEA model is then specified with the following mathematical programming problem, for a given i-th school:

$$\begin{aligned} &\mathrm{Max}_{x\lambda,\,\theta i}\,\theta_i \\ &\text{Subject to} \quad \theta_i y_i \le Y\lambda \\ &\qquad x_i \ge X\lambda \\ &\qquad n1\lambda = 1 \\ &\qquad \lambda \ge 0 \qquad (1) \end{aligned}$$

In problem (1), $\theta_i$ is a scalar satisfying $\theta_i \le 1$ .It is the efficiency score that estimate technical efficiency of the i-th school as the distance to the efficiency frontier. The frontier or the possible production frontier is being defined as a linear combination of best practice schools. With $\theta_i < 1$, the school is inside the frontier (which mean this is inefficient school), while $\theta_i = 1$ implies that the school is on the frontier (i.e. it is the most efficient school in the group).

The vector λ is a (n x 1) vector of constants, which measures the weights used to determine the location of an inefficient school if it were to become efficient. The inefficient school would be projected on the production frontier as a linear combination of its peers using those weights. The peers are other schools, which are more efficient and therefore used as references.

n1 is a n-dimensional vector of schools. The restriction $n1\lambda = 1$ imposes convexity of the frontier, accounting for variable returns to scale. Dropping this restriction would amount to admit that returns to scale were constant.

Notice that problem (1) has to be solved for each of the n schools in order to obtain n efficiency scores.

Inputs and outputs selection to DEA model is very important. The inputs most frequently used are teacher-student ratio, qualification of teachers, school expenditure and equipments. The outputs usually employed are scores on such tests as SAT or graduate exams. Some studies also use attendance and graduation rates (Maragos and Despotis, 2003; Rassouli-Currier, 2007; Sarrico and Rosa, 2008; Alexander et al., 2007; Stupnytskyy, 2004; Eff, 2002; Primont and Domazlicky, 2006; Afonso and Aubyn, 2006). These outputs capture a broad range of school production.

Sarrico (2007) suggest that it is important that DEA model will assure the consistency and comparability of any standard used: the values of the educational performance measure for each school need to be validly compared across schools.

## Research Methodology

### The data set

The data for the study were obtained from following sources. The National Institute of Educational Testing Service (NIETS) and the office for National Education Standards and Quality Assessment (ONESQA).

The NIETS data contains information about national standardized scores in three subjects (mathematic, Thai language and science). It was collected in 2008 and each student must take these exams in order to finish 6th grade and 12th grade. Note that the NIETS examination was specially conceive to monitor the outcomes of Thai educational systems in terms of student achievement on a regular basic. The mean of these three subjects for each school were calculated as the output of the DEA model.

The ONESQA data contains information about on school resources such as number of students, number of teachers, number of academic staffs and school expenditure. The data refers to the 2007/08 school year. The ratio of teachers per student, the ratio of academic staffs per student and the ratio of School expenditure per student were calculated as the output of the DEA model. There are three inputs - teachers per student ratio, academic staff per student ratio and school expenditure per student ratio – and three outputs - Score in mathematics, Score in Thai language and Score in science.

A description of input and output variables is presented in the table 1(see in next page).

### Sample

Power analysis was used for determination of the minimum sample size required for measure the association between school size and efficiency score will be considered meaningful. To detect a moderate correlation (r=0.3), a sample size of 164 schools will provide 99% power to discover that the correlation is significantly different from being no correlation at 0.05 level.

164 of 667 basic education schools in Bangkok metropolitan region were randomly assigned to the study (86 primary schools and 78 secondary schools).

**Table 1: Variable for Public Expenditure Efficiency Model**

| Variable | Explanation |
|---|---|
| DEA model Input | |
| 1. Teachers per student ratio | Number of teachers divided by the total number of student |
| 2. Academic staff per student ratio | Number of academic staffs divided by the total number of student |
| 3. School expenditure per student ratio | Total expenditure each school are given divided the total number of student |
| DEA model Output | |
| 1. Score in mathematics | School average national standardized score in mathematic |
| 2. Score in Thai language | School average national standardized score in Thai language |
| 3. Score in science | School average national standardized score in science |
| Contextual factor for correlation analysis | |
| 1. School size | Total number of students enrolled in the school |

**Data Analysis**

To identify the best performance schools, The Data Envelopment Analysis (DEA) methodology enables to aggregate performance indicators in order to obtain a public expenditure efficiency measure through the comparison of randomized schools.

An output oriented DEA model (Charnes et al., 1978) that assumes constant return to scale (CRS) was taken to estimate school efficiency score for public expenditure efficiency model. There are some studies, which use DEA model with variable returns to scale (VRS) assumption to estimate school efficiency score (Ray, 2004; Cooper et al., 2004).

However, since the public expenditure efficiency model use ratio variables, and thus scale of the school is not a school is not accounted for in any of the variable, CRS assumption was used in this paper. Moreover, an output orientation was used since the aim of this paper is not to reduce or minimize resources in each school, but to improve the educational quality: at the current recourse level, how much outputs would be increased if each school is efficient.

Because of the outputs of secondary school and primary school were measured in different level, the efficiency score estimations must be calculated separately but all variables were identical. Both DEA models were computed using DEAP 2.1 computer program (Coeli, 1996).

Pearson product moment correlation was used to assess whether there is a relationship between efficiency score and school size at 5% significance level.

**Result**

The results of the public expenditure efficiency model are presented in Table 2. The table includes minimum, maximum, mean and standard deviation of school efficiency score as well as inputs, outputs and school size for all most and five least efficient primary and secondary schools.

Teachers per student ratios range from 0.021 to 0.079 for primary school and 0.020 to 0.097 for secondary school. The averages of this ratio are 0.038 and 0.041 respectively.

Academic staff per student ratio goes from 0 to 0.012 for primary school and 0 to 0.020 for secondary school. The means of this ratio are 0.004 and 0.003 respectively, meaning that there is no academic staff in most schools.

School expenditure per student ratio, this input represent public expenditure in educational system. The average of expenditure for primary school is 15,162 Bath per student with a minimum of 1,981 and a maximum of 35,635. For the secondary school, the mean of ratio is 16,360 Bath per student with a minimum of 1,022 and a maximum of 49,536. There is much variability between schools on this variable depends on the number of students at that school.

The score in mathematic goes from 31.226 to 72.741.The average scores is 45.247 in primary school. This subject ranges from 30.360 to 46.090, with a mean of 36.479. There is more variability in primary school.

The score in Thai language goes from 30.000 to 56.076.The average scores is 43.037 in primary school. For the secondary school, this subject ranges from 36.077 to 67.752, with a mean of 50.362.

The mean score in science is 53.230, ranging from 35.962 to 73.571 in primary school. Moreover, the average score is 32.772 with a minimum of 25.294 and maximum of 47.479 in secondary school. These mean scores are quite low.

For the primary school, efficiency scores are generally high, ranging from 0.28 to 1, with 15 out of the 86 schools are being in the frontier of observed performance. The average efficiency scores are estimated at 0.706 and the standard deviation is 0.224 (assuming constant return to scale DEA models) which indicate that the average inefficiency is 29.4%.

For the secondary school, efficiency scores are ranging from 0.191 to 1, with 9 out of the 78 schools are being the best performance schools. The average efficiency scores are estimated at 0.713 and the standard deviation is 0.185 (assuming constant return to scale DEA models) which indicate that the average inefficiency is 28.7%.

It is clear from Table 2 that schools achieve best performance (efficiency score = 1) either if their output is high or if their inputs is low. This corresponds to the definition of efficiency, which says that a school being efficient achieves maximum possible output with its level of inputs. Schools 7, 8, 24, 83, 98, 111, 118 and 130 achieve efficiency of 1 because their outputs are high. The other Schools also achieve efficiency of 1, even though they do not have highest output, but their inputs are very low. The least efficient schools achieved lower than average scores even though their inputs are high.

The result of the correlation analysis, the relationship between school size and efficiency score is found to be significant at 0.05 level ($r = 0.356$, $p < 0.001$) which means that the bigger school is, more efficient the school would be.

(See table 2 in last page)

**Conclusion**

The data envelopment analysis is an appropriate method to estimate performance of public expenditure efficiency in Thai basic education. First, it can model multi-input and multi-output nature of school production. Second, it produces a true measure of efficiency.

The efficiency analysis of 164 Thai basic education schools in Bangkok metropolitan region found that the average efficiency of these schools is 0.706 (primary school) and 0.713 (secondary school) which is quite high. However, efficiency scores of individual schools range from 0.191 to 1, which shows that some schools are significantly less productive.

The correlation analysis found the significant positive relationship between school size and efficiency score.

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**Table 2**: **Results for Public Expenditure Efficiency Model and Descriptive Statistics**

| School | Efficiency Score | Inputs | | | Outputs | | | |
|---|---|---|---|---|---|---|---|---|
| | | Teachers per student | Academic staff per student | School expenditure per student | Score in mathematics | Score in Thai language | Score in science | School size |
| Primary school (n=86) | | | | | | | | |
| Minimum | 0.280 | 0.021 | 0.000 | 1,981 | 31.226 | 30.000 | 35.962 | 71 |
| Maximum | 1.000 | 0.079 | 0.012 | 35,635 | 72.741 | 56.076 | 73.571 | 3,919 |
| Mean | 0.706 | 0.038 | 0.004 | 15,162 | 45.247 | 43.037 | 53.230 | 676 |
| S. d. | 0.224 | 0.015 | 0.004 | 9,466 | 8.268 | 5.630 | 8.129 | 675 |
| The most efficient primary schools | | | | | | | | |
| 7 | 1 | 0.031 | 0.006 | 2,842 | 59.800 | 53.950 | 65.452 | 1,600 |
| 8 | 1 | 0.027 | 0.004 | 2,604 | 51.600 | 50.140 | 60.350 | 1,617 |
| 23 | 1 | 0.019 | 0.001 | 7,191 | 38.700 | 37.899 | 46.660 | 1,154 |
| 24 | 1 | 0.025 | 0.001 | 8,602 | 58.100 | 42.454 | 65.413 | 768 |
| 28 | 1 | 0.025 | 0.000 | 17,538 | 41.600 | 40.000 | 53.288 | 529 |
| 29 | 1 | 0.032 | 0.002 | 1,390 | 41.000 | 47.634 | 56.265 | 1,121 |
| 31 | 1 | 0.028 | 0.007 | 1,057 | 47.400 | 47.131 | 50.287 | 612 |
| 35 | 1 | 0.027 | 0.000 | 12,906 | 48.600 | 41.739 | 47.464 | 563 |
| 38 | 1 | 0.029 | 0.000 | 1,559 | 43.100 | 44.562 | 58.133 | 1,414 |
| 64 | 1 | 0.023 | 0.003 | 9,177 | 45.200 | 42.155 | 60.776 | 395 |
| 80 | 1 | 0.027 | 0.000 | 7,345 | 46.000 | 45.313 | 50.104 | 185 |
| 81 | 1 | 0.020 | 0.002 | 2,186 | 35.700 | 39.310 | 44.569 | 551 |
| 83 | 1 | 0.049 | 0.000 | 1,644 | 56.000 | 46.750 | 57.375 | 142 |
| 84 | 1 | 0.021 | 0.000 | 1,096 | 32.300 | 35.645 | 39.597 | 237 |
| 85 | 1 | 0.056 | 0.011 | 1,022 | 45.300 | 39.667 | 50.167 | 89 |
| Five least efficiency primary schools | | | | | | | | |
| 68 | 0.330 | 0.068 | 0.008 | 26,998 | 43.400 | 44.400 | 52.400 | 118 |
| 72 | 0.326 | 0.057 | 0.006 | 15,743 | 40.700 | 33.696 | 40.761 | 174 |
| 54 | 0.293 | 0.053 | 0.005 | 19,927 | 32.600 | 30.000 | 35.962 | 207 |
| 60 | 0.236 | 0.087 | 0.007 | 26,087 | 39.000 | 40.595 | 46.786 | 138 |
| 62 | 0.191 | 0.098 | 0.012 | 49,536 | 32.300 | 36.900 | 41.200 | 82 |
| Secondary school (n=78) | | | | | | | | |
| Minimum | 0.191 | 0.020 | 0.000 | 1,022 | 30.360 | 36.077 | 25.294 | 181 |
| Maximum | 1.000 | 0.097 | 0.020 | 49,536 | 46.090 | 67.752 | 47.479 | 4,961 |
| Mean | 0.713 | 0.041 | 0.005 | 16,360 | 36.479 | 50.362 | 32.772 | 2,317 |
| S. d. | 0.185 | 0.010 | 0.003 | 8,091 | 4.056 | 7.427 | 5.548 | 1,102 |
| The most efficient primary schools | | | | | | | | |
| 98 | 1 | 0.042 | 0.000 | 18,736 | 40.000 | 57.243 | 36.513 | 2,048 |
| 105 | 1 | 0.059 | 0.000 | 20,159 | 34.700 | 46.137 | 30.457 | 2,273 |
| 106 | 1 | 0.035 | 0.000 | 26,150 | 33.800 | 46.366 | 29.538 | 1,840 |
| 111 | 1 | 0.035 | 0.003 | 5,629 | 44.200 | 62.640 | 47.479 | 4,961 |
| 115 | 1 | 0.033 | 0.001 | 12,341 | 39.300 | 56.671 | 39.256 | 3,473 |
| 118 | 1 | 0.032 | 0.003 | 13,111 | 41.400 | 60.224 | 41.673 | 4,130 |
| 120 | 1 | 0.030 | 0.003 | 2,010 | 36.100 | 50.754 | 32.149 | 3,538 |
| 130 | 1 | 0.037 | 0.003 | 2,274 | 39.300 | 56.558 | 35.263 | 2,886 |
| 155 | 1 | 0.021 | 0.002 | 1,981 | 30.400 | 41.529 | 25.294 | 1,550 |
| Five least efficiency primary schools | | | | | | | | |
| 137 | 0.413 | 0.056 | 0.009 | 6,527 | 30.800 | 36.077 | 30.800 | 214 |
| 91 | 0.406 | 0.057 | 0.008 | 24,545 | 33.100 | 43.418 | 33.100 | 1,190 |
| 92 | 0.401 | 0.056 | 0.011 | 29,288 | 32.100 | 43.000 | 32.100 | 928 |
| 154 | 0.315 | 0.066 | 0.011 | 14,818 | 30.400 | 39.480 | 30.400 | 181 |
| 87 | 0.280 | 0.079 | 0.009 | 8,106 | 32.300 | 44.286 | 32.300 | 1,530 |